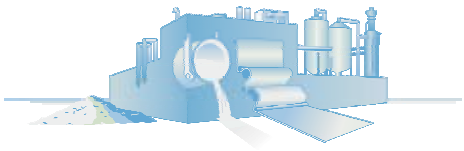
Laser Ultrasonic Web Stiffness Sensor

A Non-contact Sensor for Monitoring the Mechanical Behavior of Paper During Production to Improve Manufacturing Process Control

Every year, on grades that are stiffness sensitive, paper manufacturers run their paper webs by up to 10% above specified basis weight. This wide safety margin is needed because of the lack of on-line stiffness measurement methods, to avoid costly rejects by customers on the account of paper stiffness below acceptable limits. Current methods to measure the mechanical properties of paper, which is one of the most important parameters for process and quality control during production, use off-line samples cut from the reel after the paper has already been manufactured. The measurements are conducted manually, slowly, and cannot provide feedback for control during manufacturing. Also, the measured properties relate to paper stiffness only remotely and can be quite unreliable.

An innovative, non-contact technique that employs laser ultrasonics would allow monitoring of paper stiffness properties on a moving web without damage to the web. Manufacturers could refocus the manufacturing process onto stiffness targets rather than basis weight targets and adjust paper machines accordingly during production. Real-time control of paper machines would enable more efficient use of materials, including a higher percentage of recycled fibers, which could result in less repulping and remanufacturing. Manufacturers could optimize their use of raw materials by using less fibers and displacing some of the fibers with fillers (particles) in the web, conserving energy, and producing higher quality, more uniformed paper products.

View of the alpha prototype of the laser ultrasonics stiffness sensor installed in a paper mill in February 2005.



Benefits for Our Industry and Our Nation

- Enables monitoring of papermaking processes on the dry end of the paper machine
- Optimizes use of pulp feedstock
- Reduces refining and remanufacturing
- Reduces energy use and cost
- Improves quality and consistency
- Simplifies development of full-sheet systems
- Increases use of recycled fiber
- Minimizes waste, including “hidden waste” of lost fiber quality during drying and rewetting

Applications in Our Nation’s Industry

A non-contact method for measuring paper stiffness used industry-wide could reduce the consumption of trees and chemicals and save the U.S. paper industry approximately $200 million in energy costs and $330 million in fiber costs each year.

Project Description

Goal: Demonstrate a robust industrial laser ultrasonic sensor for on-line measurement of paper stiffness, leading ultimately to commercialization.

The project is a combined effort of organizations with complementary expertise in paper physics and laser ultrasonics. Tasks include optimizing ultrasound generation on moving paper, developing interferometric detection schemes for on-line operation, and constructing a prototype for application on a paper machine. Researchers will develop a sensor that uses laser ultrasonics to excite and detect Lamb waves propagating in the paper plane. Once the sensor measures wave velocity, the velocity will be used to determine real-time paper stiffness, which is a very important factor determining paper end-product properties. Sensors installed on commercial papermaking machines will provide manufacturers with real-time paper stiffness information. Manufacturers can use this information to determine short- and long-term trends and adjust their paper-making processes to ensure the utmost efficiency and quality. The potential for the laser ultrasonic sensor to significantly improve the papermaking process was recognized in 2006 when the technology received an R&D100 Award. In addition, the sensor could potentially be applied to other materials than paper webs, such as metal webs and some plastic webs.

Pathways and Milestones

- Demonstrated a prototype sensor on a MeadWestvaco pilot coater (Completed August 2001)
- Conducted mill demonstration of the alpha prototype of the sensor on a paper machine during production (Completed February 2005)
- Completed final analysis of the results of the mill demonstration of the alpha prototype (Completed July 2005)
- Awards, Patents, and Invention Records:
  - U.S. patent number 6,115,127: "Non-contact measurements of ultrasonic waves on paper webs using a photorefractive interferometer."
  - U.S. patent number 6,356,846: "System and method of reducing motion-induced noise in the optical detection of an ultrasound signal in a moving body of material."
  - 2004 Outstanding Research Paper published in 2003, presented by TAPPI
  - 2004 Van den Akker International Prize for Advances in Paper Physics
  - R&D100 Award (2006) for alpha prototype of laser ultrasonics web stiffness sensor

Commercialization

Commercialization of a laser ultrasonic device would begin following the completion of this project. ABB Industrial Systems, Inc., which currently markets cross direction instrument scanners worldwide, would include the device in some of their scanners as part of a device package. The commercialization of the device would require approximately two years following project completion.

Project Partners

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ABB Industrial Systems, Inc.
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A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

U.S. Department of Energy
Energy Efficiency and Renewable Energy
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

Ending in FY2006

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